**Activity #7**

**Title: Detecting the Invisible-Teacher's Copy**

**(Teacher demo with class's interaction)**

**Purpose:**

- To be able to predict the color of light transmitted through various gels (filters).
- To demonstrate that an invisible energy (infrared) is located beyond the red band in the visible light spectrum.

Note to the teacher: This activity will require the construction of a simple photocell detector capable of detecting wavelengths of light in the visible and infrared range. The relatively small expense incurred here will be justified by the fact that this photocell detector will also be used for subsequent activities in this series. Instructions for the building of this device follow. A simple diffraction grating spectrum projector will also be required…with directions for construction below.

Materials Needed:

- **Solar Cell**, 0.5V, 300mA, Radio Shack # 980-0880, $5.99, 1-800-THESHACK or http://www.radioshack.com/product.asp?catalog%5Fname=CTLG&category%5Fname=&product%5Fid=980%2D0880
- **Amplified Speaker**, Radio Shack # 277-1008C, 200 mW output, 5 kΩ, 9 VDC, 1-800-THESHACK or http://www.radioshack.com/ProdSupport/DocumentDetail/DocumentDetailIndex.asp?URL=http://support.radioshack.com/support_supplies/15593.htm
- **Audio Cable,** Radio Shack # 42-2434, 1/8" mini-plug/exposed wires on opposite end, $2.99, 1-800-THESHACK or http://www.radioshack.com/product.asp?catalog%5Fname=CTLG&category%5Fname=CTLG%5F002%5F001%5F002%5F000&product%5Fid=42%2D2434
- **1" Alligator Insulated Test/Jumper Cable Set**, Radio Shack # 278-001, set of 4, $3.99, 1-800-RADIOSHACK or http://www.radioshack.com/product.asp?catalog%5Fname=CTLG&category%5Fname=CTLG%5F005%5F007%5F020%5F000&product%5Fid=278%2D001
- **Diffraction Grating (holographic),** 5" x 5", 2 sheets/pkg., $9.00, Learning Technologies, Inc., 20 Cameron Ave., Somerville, MA 02144, 1-800-537-8703 or www.starlab.com See also: http://www.rainbowsymphony.com/scied.html for many light-related activity resources such as diffraction gratings, solar viewing glasses, polarized film, 3-D glasses, etc.
- **Red and Green GamColor filters**, #250 medium red XT and # 650 grass green, 20' x 24" sheet, $6.25 each, Great American Market, 826 N. Cole Ave., Hollywood, CA 90038, 1-888-GAMCOLOR or http://www.gamonline.com/index1.php
- **9 V battery**, local sources
- **wire nuts**, small, local hardware store item
- **Overhead projector**, standard classroom equipment
- **Masking tape,** 2" width, local hardware store item

**Photocell Detector Construction:**

- Use the wire nuts to connect each of the two leads from the solar cell to each of the exposed ends of wire on the audio cable.
- Plug the 1/8" mini-plug into the "input" jack of the amplified speaker (see Photo #1 and Photo # 1A below)
- Insert the 9V battery into the amplified speaker…and you're in business!

Photo #1

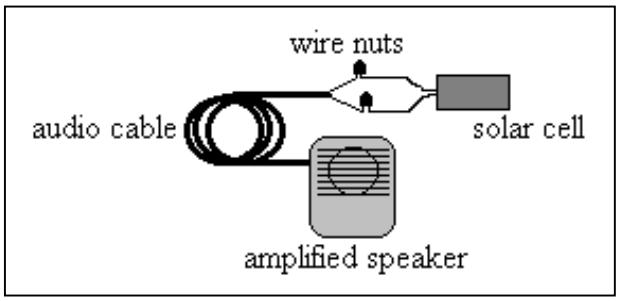
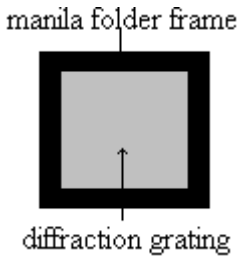



Photo #1A

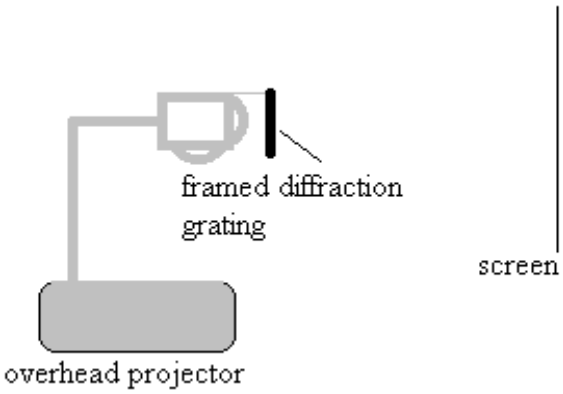
The photocell (solar cell) produces an electric current when it is exposed to light. This electric signal is sent to the amplified speaker and creates one "pop." If the light signal is "chopped," the speaker produces a series of pops. If the light source is chopped very rapidly (as with a large-bladed fan placed between the light source and the solar cell), a hum is produced by the speaker. A constant source of light (such as from a flashlight) produces no noticeable sound on the speaker, but a pulsing light source (like the fluorescent overhead lights in most classrooms which "pulse" approx. 120 times per sec.) creates a continuous hum on the speaker. Passing your hand between a flashlight pointed at the solar cell produces one pop. Rapidly moving your hand back-and-forth in the beam of light will produce a series of pops that should be audible throughout the entire classroom.

**Diffraction Grating Spectrum Projector Construction:**

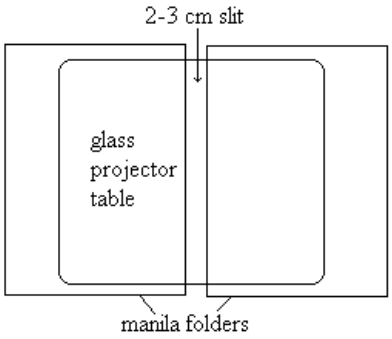
- Mount one 5" x 5" holographic diffraction grating in a frame made from a manila folder. (This gives the grating some support and allows it to be easily taped to the overhead projector head without curling.)




- This diffraction grating can be taped by its frame to the projection head of the overhead projector (between the head and the screen) as shown below.




- Two manila folders can be taped to the glass table of the overhead projector, leaving a vertical space of about 2-3 cm between them. This will create a projected vertical slit of light that will get dispersed as it passes through the diffraction grating. Rotate the grating so that the projected spectrum is displayed on the screen in a horizontal attitude. This works best in a darkened room.




**National Standards addressed:**

**Science as Inquiry**

CONTENT STANDARD A:
As a result of activities in grades 5-8, all students should develop

- abilities necessary to do scientific inquiry through the use of appropriate tools and techniques
- abilities necessary to gather, analyze, and interpret data.
- understandings about scientific inquiry by the development of descriptions, explanations, predictions, and models using evidence.

**Physical Science**

CONTENT STANDARD B:
As a result of their activities in grades 5-8, all students should develop an understanding of:

TRANSFER OF ENERGY

- Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object--emitted by or scattered from it--must enter the eye.

**Procedure/Inquiry: Part I**

1. Your teacher will shine a flashlight (**in a darkened room**) on the photocell attached to the amplified speaker. Describe what you hear. The room should be darkened as much as possible, including turning off televisions and computer monitors in the area. You will shine a constant light beam from a battery-operated (DC voltage) on the photocell at this time.

2. Describe what you hear when the teacher moves a hand through the beam of light entering the solar cell. You will pass your hand ONCE through the flashlight beam before it strikes the photocell. Background sounds from gurgling fish tanks, ventilator blowers, etc. should be kept to a minimum, if possible, as this sound produced here is very soft.

3. When the teacher moves a hand rapidly back and forth through the beam of light that enters the photocell, describe what you hear. Here you will pass your hand through the light beam in a rapid fashion (about 4 times per second).

4. Explain what must happen in order to be able to "hear" light energy. Be sure to include the components necessary to perform this task successfully.

5. Your teacher will now project a slit of light from the overhead projector through a diffraction grating and onto the classroom screen or wall. Describe the image that appears on the screen. See "Diffraction Grating Spectrum Projector Construction" above.

6. How is this image different than the one produced when a slit of white light was passed through a prism? (Remember Activity #5?) You MAY want to remind your class that the short wavelengths of light (violet) were refracted (bent) the most and the long wavelengths (reds and oranges) were bent the least when white light was passed through a prism

7. Now place a strip of masking tape above the image on the screen and mark the location of the red, yellow and green bands of light. Doing this will ensure that the projector, the diffraction grating and the screen remain in the same position throughout this activity. Describe what you hear when the teacher holds the photocell (with amplified speaker connected) in the red, the yellow and the green bands of the image while passing a hand through the incoming beam of light. Mark the masking tape boldly with a broad-tipped marker "R," "Y," and "G" respectively so the characters are visible to those in the rear of the room. Hold the photocell detector in one hand against the screen (first in front of the red band, then in front of the yellow and finally in front of the green band) while you pass the other hand rapidly through the incoming beam.

8. Predict what you will hear, if anything at all, when the photocell detector is held in the dark region to the immediate right of the red band of visible light.

9. After placing the detector in the dark region beyond the red band of visible light and chopping the beam with a hand, you can now determine: Was your prediction correct? Here you will place the

detector in the region just beyond (to the right) of the visible red band of the spectrum projected upon the screen. Chop the incoming invisible beam (of infrared) with your free hand.

10 How do you know that some form of energy must be present in the region beyond the red band on the spectrum?

11. If this invisible energy is "beyond the red" portion of the visible spectrum, what do suppose it is? (Think back to Activity #4 involving the electromagnetic spectrum!) Explain your response.

**Procedure/Inquiry: Part II**

1. Predict what will appear on the screen when a red gel (filter) is placed between the diffraction grating and the screen. (Remember "Activity #6-Observing Colors?")

2. Now state what actually did appear on the screen with the red filter in place. Hold the red gel (close to the projector head) between the diffraction grating and the screen.

3. Predict what will appear on the screen with a green filter held between the diffraction grating and the screen.

4. What was actually observed after placing the green filter as described above? Hold the green gel (close to the projector head) between the diffraction grating and the screen.

5. Predict what will appear on the screen when BOTH the red and green filters are placed between the grating and the screen.

6. With both gels in place as described above, tell what appeared on the screen. Hold both the red and green gels, sandwiched one in front of the other, (close to the projector head) between the diffraction grating and the screen.

7. Do you think that the photocell detector will produce a popping sound when held (and the incoming beam "chopped" by one's hand) in the regions on the screen where the red, green and yellow were originally displayed? **Note:** The red and green filters are still in place between the diffraction grating and the screen.) Why or why not?

8. What did you hear when the photocell detector was held in the visible light sections of the display on the screen? Have a student hold the red and green gels in place while you place the photocell detector in front of each region on the screen where the bands of color were once displayed. (This is why the masking tape with R-Y-G markings was originally placed on the screen—to be able to locate the respective regions once the gels absorbed the incoming light.) Pass your hand in front of the detector as in the previous procedures.

9. Predict what you will hear (with the red and green gels in place) when the photocell detector is held in the dark region beyond (to the right) of the red band location on the screen.

10. Was any popping actually heard when procedure #9 was performed? ? Have a student hold the red and green gels in place while you place the photocell detector in front of the region to the right of the red band region on the screen. Pass your hand in front of the detector as in the previous procedures.

11. What does this tell you about the ability of this "invisible light" beyond the red band of the spectrum to pass through filters (gels)?

12. Tell why you think it may or may not be possible for this invisible light to exist in rainbows?

Technology Integration: The following websites contain activities and resources to enhance the understanding of the scientific principles encountered in this teacher demonstration.

- http://physics.nm.ru/Physics/English/DG10/theory.htm Basic theory of diffraction gratings
- http://www.matter.org.uk/schools/Content/Interference/gratings.html Interactive program which allows the user to vary the number of slits in a diffraction grating
- http://fusioned.gat.com/Teachers/Curriculum/Curriculum-HTML/T04S-wavelength.html Measuring the wavelength of light using a diffraction grating
- http://www.homeschoolscience.com/sample_lessons/sample_light.html Diffraction glasses (eyewear) and simple inquiry activities
- http://www.geom.umn.edu/education/calc-init/rainbow/experiment.html Explains the reflection of light within raindrops to produce the rainbow
- http://www.chennaionline.com/science/rainbow.asp How rainbows are formed